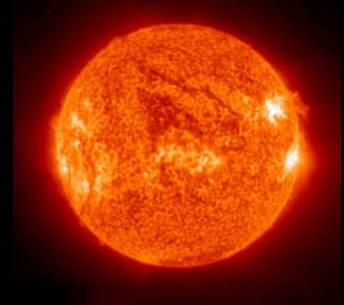




Adaptability of California's Hydropower System to Climate Warming



Kaveh Madani, PhD Student
Dept. of Civil and Environmental Engineering, UC Davis
kmadni@ucdavis.edu

Jay Lund, Professor
Dept. of Civil and Environmental Engineering, UC Davis
jrlund@ucdavis.edu

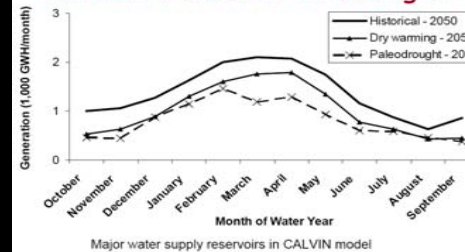
Abstract:

Climate warming in California will shift runoff peaks from spring to winter, because of the demise of the snowpack's seasonal reservoir. While water supply reservoirs seem to be flexible to this change due to their high storage capacity, most high-elevation hydropower facilities which have been designed to take advantage of current snowmelt patterns have relatively little storage to compensate for this seasonal shift in streamflows. The effects of climate warming on seasonal hydropower generation is estimated and presented to find out how adaptable the hydropower system is to climate warming.

Methods

- CALVIN, an economic optimization model was used to estimate the seasonal generation changes of water supply dams which are mostly located at low-elevation.
- Generation changes at high-elevation (above 1000 ft) were estimated based on two different approaches:
 - No-Storage Approach:** It was assumed that there is no storage capacity available at high-elevation. Monthly historic (Base) generation was perturbed based on the ratios for Dry and Wet climate change scenarios.
 - No-Spill Approach:** It was assumed that the high-elevation storage capacity is high enough that there is no energy spill from the reservoirs. The energy storage capacities at different elevation ranges were calculated by comparing the monthly generation and runoff curves. Using the perturbed inflows, monthly generations simulated for different scenarios.

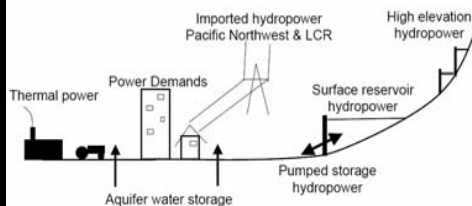
Water Supply Dam Hydropower Seasonal Generation Changes



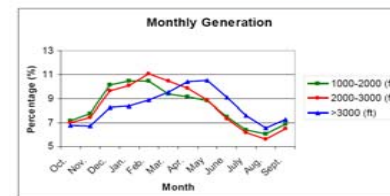
Generation Changes with Climate Change

- Water supply dam generation mostly changes with runoff – seasonal shifts for drier warming can be accommodated by storage
- High elevation hydropower is less seasonally flexible
- Overall hydropower generation increases in winter and is much less in summer and spring
- Movement of drought water storage to aquifers reduces hydropower from water supply dams, and increases drought pumping demands

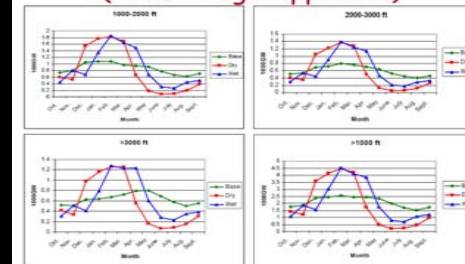
Hydropower Systems



Historic Generation by Elevation



Simulated Generation (No-Storage Approach)



Findings & Insights

- There are potential effects of climate change on hydropower system in California.
- There is a considerable storage capacity available at each elevation range which plays an important role at current situation. However, this storage capacity might not be enough for the changing climate.
- The drawdown and refill seasons of reservoirs will be changes by climate change.
- Present hydropower system has been designed to take advantage of current snowmelt patterns and might not be flexible enough to climate warming.
- Climate changes affect hydropower generation and electricity demand.
- Climate warming increases summer electricity demand while decreasing winter demands.

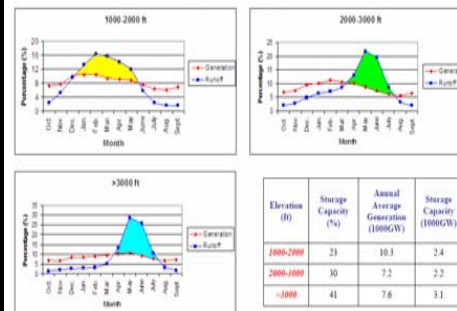
Hydropower and California

1,000 GWh/yr, 2004

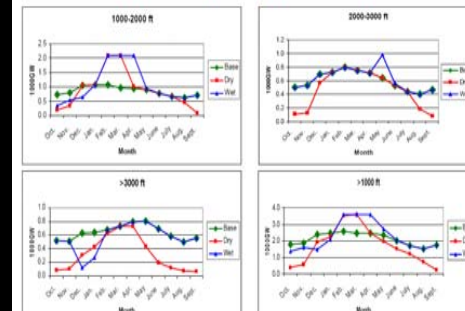
Hydropower Total	45.4
In-state Hydropower	34.4
High Elevation*	25.3
Low Elevation*	9.1
Pumped Storage	?
Imported Hydropower	11
PNW	9.5
LCR	1.5
Thermal	205.2
Other renewables	24.5
Total	275.1

* Estimated Sources: CEC, McCann 2005

Storage Calculations (No-Spill Approach)



Simulated Generation (No-Spill Approach)



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- CALVIN Group

<http://cee.engr.ucdavis.edu/faculty/lund/CALVIN/>